Platform Preannouncement Strategies: A Duopoly of Two-Sided Markets

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Abstract

Platform-firms' strategic choices differ from that of product-firms. While products serve *a* market, platforms need to account for the impact of their actions on two (or more) distinct but connected sides. Further, in a competitive market, the preannouncement of a new platform by firms such as videogame console makers, needs to not only take into account game-developers' reactions and gamers' expectations but also competitive response. In the age of Web-forums and social media, in addition to formal preannouncement, platform firms also engage in informal preannouncement where no explicit commitment of new feature-sets, prices and other information are put-forth. Our work finds that firms' optimal strategies and equilibrium outcomes are a function of users' (developers') strength of taste-preferences. We find that the informal preannouncement strategy is generally preferred as it is able to mitigate some aspects of the price competition. However, in duopolies where users (developers) have strong taste-preferences, the equilibrium outcome is one where both firms pursue formal preannouncement strategies. Both prices and licensing fees are higher when pursuing informal preannouncement strategy and social welfare is always higher in the formal preannouncement game as long the overall preannouncement costs are small.

Keywords: *preannouncement, platforms, two-sided markets, network effects, fulfilled expectations, competition, pricing*

1. Introduction

It is common for firms to preannounce the forthcoming release of their products. While the strategic intent of such preannouncements can include prevention of switching to a competitor and creating a barrier to entry, the primary purpose underlying such preannouncements is to simply inform of the market of a new product, its features, prices, etc. Generally preannouncement (Eliashberg and Robertson 1988, p.282) takes the form of a "*formal, deliberate communication before a firm actually undertakes a particular marketing action.*". These marketing actions may include advertising, pricing, service details, etc., all of which are geared towards informing the customers (and competitors) in the marketplace.

We routinely see such preannouncements in certain high-tech and information goods industries such as video games consoles (PlayStation, Xbox, Nintendo, etc.), computer operating systems (Windows, MacOS), mobile operating systems (Android, iOS, Windows Mobile), etc., where there is periodic release of new versions. What is particularly different about these preannouncements is that these industries represent platforms, rather than products, also sometimes referred to as two-sided markets. The key point of relevance being that while product preannouncements are targeted towards one group of users, platform preannouncements are intended to reach, inform and educate two (or more) separate sides of the platform. Platform preannouncements in many of these technology-based industries are not only intended to influence consumers of these goods but also developers who create apps, games or applications as the case may be. For example, when Sony formally preannounced the release of its PS3 (Morris 2005), it not only revealed technical details such as digital formats supported, (e.g., DVD, Blu-Ray, CD), hardware specifications (e.g., memory slots supported, CPU details, Graphic accelerator performance, auxiliary Bluetooth support), and multi-media features (e.g., video chat, internet access, photo view-

ing) but it also specifically highlighted its API (application programming interface) and endorsements from early developers who observed that the platform "*... was easy to program for.*" (Thorsen 2005) While distinct, these groups' decisions are not independent of each other and therefore any strategic purpose of preannouncing platform, e.g. competitive response in a duopoly, must account for beliefs and expectations from both sides of the market. To our knowledge, there is little or no work that has examined preannouncement in the context of platform and platform competition.

In addition to the commonly observed '*formal'* and '*deliberate'* forms of preannouncement, the emergence of Web-based forums in general and social media in particular has allowed for another form preannouncement. We can observe that sometimes firms, instead of making a formal preannouncement, will either deliberately leak information about its forthcoming product and/or make a somewhat vague and non-committal preannouncement of a new version. It has been revealed that even a firm like Apple, with its reputation for never commenting on pre-release products, uses '*controlled leaks*' to test the market and yet maintain plausible deniability (Etherington 2010). Sometimes firms are also known to strategically inform the market in a diffused fashion without a proper commitment on features and/or price. For instance, Microsoft eschewed the use of a formal preannouncement for its Xbox 360. While the media called it '*weeks and weeks of Xbox 360 rumors*,' Microsoft itself seemed less concerned and appeared to be sure that game studios and developers will understand their preannouncement (Reimer 2006). While indeed the trade press observed that gamers were less sure about features of the impending release, the developer community appeared to have a better understanding, commenting on specific feature-sets likely in the new release (IGN 2005). We can observe similar differences between end-consumer understanding and developer insights for a variety of other product categories such as PC operating systems, mobile devices, etc. At a cursory level, it might be puzzling that firms

adopt a preannouncement strategy that is not clear to its consuming segment but the key benefits of such a strategy include the reduced cost of an informal commitment and the advantages from delayed differentiation (Swaminathan and Tayur 1998).

While extant research have not explicitly modeled informal preannouncements in the context of platforms, there exists a strong literature on product preannouncement in both marketing and information systems literature. Moreover, platforms are network goods where value to both sides of the market are intrinsically linked to the size of the market on the same-side and cross-side. And therefore any examination of preannouncements of platforms should incorporate the findings from a rich literature on network effects.

1.1 Review of relevant literature

The literature on product preannouncements has focused on the '*if*' and *'when'* aspect of the preannouncement. While these communications can clearly be beneficial to a firm's potential market, the fact that this information is now available to competitors as well can be a source of concern – and hence the '*if*' part of the preannouncement strategy (Gerlach 2004). Extant research has also then examined strategies such (a) lying – where the firm preannounces a new version but does not actually release one – a strategy called *vaporware*, and (b) maintaining silence – where a firm make no preannouncement and releases a new product – a strategy called *suddenware* (Ofek and Turut 2013). The former is generally considered useful to deter a new entrant (Bayus, Jain et al. 2001) and is advantageous in certain situations such as low ex-post cost of vaporware (Gerlach 2004) and low product development cost in which case the firm can enter later than its original preannounced time and still earn monopoly profits (Bayus, Jain et al. 2001). The latter strategy is employed to prevent aggressive investments by an entrant is an equilibrium strategy when the incumbent has strong forecasting capabilities and the "*ability to impact cus-*

tomers in advance is limited" (Ofek and Turut 2013, p. 352). More than any other, such preannouncements are routine and prevalent in the technology industry where it has been observed that "*... product preannouncements has been prominent in industries characterized by network effects, such as the computer software industry.*" (Choi, Kristiansen et al. 2005, p. 314). In other words, these are industries where customer demand *is* fundamentally influenced by release of new versions.

In this context, although early work (Gerlach 2004) has described the preannouncements in technology-driven markets such as the videogames industry, generally network effects were not incorporated in the analyses of these strategies (Choi, Kristiansen et al. 2005). Moreover, many of these products in the technology industry are now less studied as products facing a single market, rather they are understood as platforms that exhibit characteristics of a two-sided market (Parker and Van Alstyne 2005). This assumes particular significance for preannouncement strategies they now are intended to influence two distinct groups and thus any model has to incorporate both same-side and cross-side network effects. Put simply a preannouncement model, for say the videogame industry, has to now abstract the fact that a gamer evaluating a new console is incentivized by more other gamers as well as more developers on the other side of the market. Similarly the model will also have to take into account the developers' evaluation of the preannouncement which includes cross-side effects from the gamer network size. Furthermore, in a competitive market, the focal firm has to take into account the two markets' interconnected response to his own as well his rival's preannouncement. In this regard, though not explicitly modeling preannouncement, two papers from the economics literature are critical to understanding competition between platforms.

Rochet and Tirole (2003) and Armstrong (2006) provide an elaborate understanding of outcomes in platform competition. In modeling competition both models incorporate aspects of

same-side and cross-side network effects while considering markets with heterogeneous taste preferences. Through a stylized Hotelling model, both papers examine pricing strategies of the two platforms as it pertains to both sides of the market. For the kinds of industries we are interested in, both papers underscore the importance of modeling competing platforms rather than single-markets – Rochet and Tirole (2003) provide a number of platform examples through mini-cases and indeed one of which is the videogame industry and while they are interested in welfare and Ramsey prices, Armstrong (2006) evaluates different tariff structures. The latter work is important to the base model setup in our paper even if it does not concern itself with the alternative preannouncement strategy introduced in this paper, namely informal preannouncement.

In models with network effects where users' utility is intrinsically linked to the market size, the eventual market outcome is commonly obtained from a fulfilled expectations equilibrium. Thus, the expectations formed by the users are key for such products (Katz and Shapiro 1985) and in our context, we need to accommodate expectation formation on two sides of the market as a result of different types of preannouncements that essentially contain differing amounts of information. In this regard, while not capturing informal preannouncement, the closest understanding of markets under different expectations is provided by a recent working paper (Suleymanova and Wey 2012) that suggests that there may be strong and weak expectations regarding market shares. In the former abstractions (Katz and Shapiro 1985), users may form expectations of market size and outcomes before incorporating competitive aspects (and therefore firms take such expectations into account in setting prices) while in the latter the expectations are shaped by actual competitive response. Equivalently, in our paper we need to incorporate the fact one set of users (end-consumers) form expectations when they do not understand informal preannouncement (and hence cannot take elements of a new version release into account) while the other side

of the market form expectations that accommodate this preannouncement, albeit in a less than perfect fashion.

2. Model

We consider a duopoly of two firms A and B that is characterized by platform competition. Each firm develops a two-sided platform that enjoys revenue from selling to a user/end-consumer side as well as by licensing (by charging a fee) to developers on the other side. They compete in a market where users are heterogeneous in their taste preferences, i.e., consumers may differ in their preference for color, design of the product (e.g., console, controller, etc.) and other horizontally differentiated factors. Each firm's platform is identical in quality and features but differ in these consumer taste factors or preferences. Similarly, the developers on the other side of the platform are heterogeneous in their preferences for programming languages, API management and other software development environments.

We abstract the distribution of these taste preferences on both the user side (subscript u) and the developer side (subscript d) through a Hotelling line such that the platforms A and B are horizontally differentiated in their product offering and are located on the extremes. The users and developers are uniformly distributed on their taste preferences and as with extant location models, each point represents the ideal product for the consumer (developer) and they suffer a disutility $\left(tx^2\right)$ when obtaining a product that is located some distance x from their ideal point. The parameter $t\left(t>0\right)$, called the transport cost coefficient in location models, captures the strength of taste preferences in our case. In other words, greater this value, stronger is a consumer' (developer) preference for their ideal product and thus greater is the disutility they suffer when they have to choose a product away from their preferred one. In our model, each consumer (developer) buys (licenses) one platform and they are single-homing.

We develop our base model along the lines of Armstrong (2006) where both sides of the platform enjoy cross-side network effects, i.e., developers gain value from more users and users gain value from developers. We use a parameter $\beta\big(\beta > 0\big)$ to denote the cross-side externality coefficient. In addition, we also introduce parameter $\alpha\big(\alpha > 0\big)$ to capture the same-side externality that exists for products such as video game consoles where consumers derive more value from using a console that enjoys a larger market. Generally while such same-side network effects are observed on the user side they are absent on the developer side. If any are present (e.g., more developers creating positive externality for labor supply) usually they end up cancelling out due to the competitive effect and hence we ignore any same-side externalities on the developer side.

2.1 Platform preannouncement strategies

Our main aim in this paper is to examine a firm's choice of preannouncement of its new platform-version. Literature in marketing states that even for products (let alone platforms), in addition to R&D related investments, new product development strategy should also include methods to communicate to the market about the firm's course of action (Ofek and Turut 2013). In our paper, a firm can do so in one of two ways – a *formal strategy* and an *informal strategy*, that signify the format of the firm's commitment and preannouncement to the marketplace of the new version of its platform.

2.1.1 Formal strategy

When a firm pursues the formal strategy, it preannounces and commits to the marketplace at large that it will release a new platform in the future period. Such a preannouncement may not only include timing related information but also information on new features and add-ons for the consumers and perhaps technical details of the development environment to the developers. The firm incurs any and all the costs associated with introducing the new version of the platform at

this time, denoted by a one-time cost c. While the firm is burdened by this cost upfront, it also stands to benefit from this strategy as this allows both consumers and developers to fully taken into account the features of the new version and conditions of the new marketplace, in setting their expectations and allocating their budgets. All activities under this strategy are denoted with subscript F.

2.1.2 Informal strategy

A firm pursuing informal strategy continues to develop a new version of its product, however it does not formally make a preannouncement about its new version. Rather, the firm relies on informal and allied mechanisms such through social media, technical forums, etc., to spread information of the upcoming new platform. The clear advantage to a firm in pursuing this strategy is that it incurs a lower formal marketing engagement cost, less locked up capital, etc. Further it can enjoy advantages of delayed differentiation as it has not made a formal commitment of its feature set – it can perhaps tweak its version in response to market closer to product release. In our model, we capture these advantages to the firm through a cost discount parameter $k\left(k \in \left[0,1\right]\right)$ such that the total preannouncement cost incurred in pursuing this strategy kc.

Generally there has been no discussion of such a strategy in the NPD or product preannouncement literature; however recent marketing literature (Ofek and Turut 2013) refers to a strategy called 'suddenware' wherein even if a firm is developing a new product it makes no preannouncement and can abruptly introduce the product in the market. However as this work and others (Schneider 2015) acknowledge product roadmap leaks are a reality and indeed with social media activity there is always a fair amount of information on the product. Our model captures this reality in that while a firm may have cost advantages to not making a formal preannouncement, it might suffer in that information on its new version is not clearly available in the marketplace. This element is particularly telling when network effects are involved as

consumers and developers are now limited in their ability to form expectations based on features and marketing information. When we lay down the timeline of firm actions we shall explicitly account for the impact of this limited information and the nature of fulfilled expectations under informal strategy. All activities under this strategy are denoted with subscript I.

2.2 Timeline

The goal of our paper is to understand a firm's choice of preannouncement strategy vis-à-vis its new platform, as a response to the market conditions and competitive behavior. In this timeline we shall elaborate on firm actions, market conditions and the information level at each stage. The timeline of event is as follows:

STAGE 0: Each firm $i \in \{A,B\}$ starts with an installed base of users and developers $\left(j \in \{u,d\}\right)$ given by m_j^i. The market size of users and developers are each normalized to 1, i.e.

$$\sum m_u^i = 1; \quad \sum m_d^i = 1; \tag{1}$$

STAGE 1: In stage 1, the firms choose their strategy for preannouncement – either a formal preannouncement $\left(F\right)$ or an informal strategy $\left(I\right)$ and correspondingly incur costs c or kc respectively. At this stage consumers and developers form expectations about the new version of the platform so as to allocate budgets for purchase in the next period. In constructing the expected utility of the consumers (developers), we need to not only account for the same-side and cross-side network effects introduced earlier but also account for the fact that these expectations are built on the expected demand. Let n_u^i and n_d^i be the consumer and developer demand facing firm i. While the firms in Stage 0 were facing a unit market, we introduce an important market change at Stage 1 where as a result of the new platforms with new features arriving (and hence bringing new consumers and developers along with), the unit market now doubles in size, i.e.

$$\sum n_u^i = 2; \qquad \sum n_d^i = 2; \tag{2}$$

It is important to note that while the actual market may double as a result of new features of the new platform version, consumers (developers) may be able to accurately form this expectation of the market only on the basis of the firm's signal. In other words expectation of market size is a function of the users' (developers') ability to understand the preannouncement signal. First, we shall consider the formal case where the signal is clear to the marketplace and both sides fully understand the release of the new platform version.

In case a formal preannouncement is made by firm i, the consumers expected utility from purchasing from this platform can be written as

$$U_{u,F}^i = \theta^i + \alpha n_u^i \left(p^i, p^{\lambda}, l^i, l^{\lambda}\right) + \beta n_d^i \left(p^i, p^{\lambda}, l^i, l^{\lambda}\right) - p^i \tag{3}$$

where p^i and l^i are the prices and licensing fees that will be set by the firm i. Note that each firm's consumer (developer) demand is a function of its own prices (licensing fees) and the other firm's prices (licensing fees). The first term refers to the intrinsic benefit from using the platform independent of any network effect. The second term captures the same-side externality benefits while the third term captures the cross-side benefit as a result of the developer demand. Similarly, we can write the expected utility of the developer as

$$U_{d,F}^i = \theta^i + \beta n_u^i \left(p^i, p^{\lambda}, l^i, l^{\lambda}\right) - l^i \tag{4}$$

However, note that the same-side externality is absent from the developer side for reasons discussed earlier.

While in the case of the formal preannouncement, the users and developers are aware of equation (2) and take that into account in forming their expectations, when a platform adopts an informal strategy it does not provide enough information to the marketplace (though it enjoys some cost advantages). Realistically, as a result of technical sophistication and close engagement

with the community, developers may be better positioned to understand these informal preannouncements that end-consumers do not. Therefore the expected utilities when firms adopt this strategy are fundamentally different. For simplicity, in the informal case, we assume that the user just expects that the platform will continue to have the same market size that it started with in Stage 0, i.e., the installed base m_u^i. Thus his expected utility can be written as

$$U_{u,I}^i = \theta^i + \alpha m_u^i + \beta m_d^i - p^i \tag{5}$$

On the other hand, developers are in a better position to understand the informal signal even if their ability is limited by the firm's effort in this direction. We assume that this effort is in direct proportion to the cost discount factor k such that a higher k implies richer and fuller information about the market size while therefore also incurring higher cost. For simplicity we assume this relationship to be linear and we can therefore write the developers' expected utility in Stage 1 as

$$U_{d,I}^i = \theta^i + k\beta n_u^i \left(p^i, p^{\backslash i}, l^i, l^{\backslash i} \right) - l^i \tag{6}$$

As discussed earlier, while there is no work that has modeled informal preannouncement strategy, one recent work in economics provides a point of comparison on how expectations are formed when analyzing markets with fulfilled expectations equilibria. In this regard, a recent work (Suleymanova and Wey 2012) suggests that there may be such a thing as *weak* and *strong expectations* in markets with network effects. Consumers forming strong expectations may *'stubbornly favor a particular market outcome'* (Suleymanova and Wey 2012, p.2) implying that such expectations maybe insensitive to firms' decisions such as pricing. In contrast, consumers with weak expectations fully form them taking into account elements such pricing decisions. The nature of these expectations are critical to market outcome. In our model, expectations regarding network size is key – the different strategies lead to different expectations and hence the price (licensing

fee) function formed at the end of Stage 1 under the two firm strategies are different. The consumer (developer) allocates his price (licensing) budget based on this function.

STAGE 2: In stage 2, independent of the preannouncement strategy pursued in Stage 1, the new platforms are released and firms reveal their prices and licensing fees. Note that there is no opportunity for consumers to revise their expectations and hence firms have to take that into account in setting the prices and licensing fees. The objective function of the firm that engages in a formal strategy can be written as

$$\max_{\left\{p^i,l^i\right\}} \pi_F^i = p^i n_u^i\left(p^i,p^{\backslash i},l^i,l^{\backslash i}\right) + l^i n_d^i\left(p^i,p^{\backslash i},l^i,l^{\backslash i}\right) - c \tag{7}$$

Similarly, the objective function of a firm that engages in informal strategy can be written as

$$\max_{\left\{p^i,l^i\right\}} \pi_I^i = p^i n_u^i\left(p^i,p^{\backslash i},l^i,l^{\backslash i}\right) + l^i n_d^i\left(p^i,p^{\backslash i},l^i,l^{\backslash i}\right) - kc \tag{8}$$

3. The preannouncement game

We model the duopoly as a simultaneous move game where a firm i chooses its strategy $S^i = \left\{F, I\right\}$ in *Stage 1* and sets prices and licensing fees in *Stage 2* taking into account the consumer/developer expectations formed in *Stage 1*. We shall first need to examine the various subgames before we backward induct and develop the subgame perfect Nash equilibrium (SPNE). There are three possible subgames – two in symmetric strategies where both firms pursue a formal strategy or both pursue informal preannouncement strategy and one in asymmetric strategies where one firm pursues formal while the other pursues an informal preannouncement strategy.

3.1 Formal-Formal subgame

When both platforms pursue a formal strategy in Stage 1, the users and developers in the market are fully aware that the market size will increase when the platforms are released in Stage 2. As

the platforms are sufficiently differentiated and located at the extremes, from the Hotelling specification (Hotelling 1990) we know that for a user indifferent between firm A and B identified by a location point x^*, it must be that

$$U^A_{u,F} - t\Big[x^*\Big]^2 = U^B_{u,F} - t\Big[1 - x^*\Big]^2 \tag{9}$$

where the utilities are those specified in equation in (3). Since the unit market size from Stage 0 has now doubled, we can write the demand function of each firm for the user-side as follows

$$n^A_u \Rightarrow 2x^* = 1 + \frac{U^A_{u,F} - U^B_{u,F}}{t}; \qquad n^B_u \Rightarrow 2(1 - x^*) = 1 - \frac{U^A_{u,F} - U^B_{u,F}}{t} \tag{10}$$

It is important to remember that in our model consumers are single-homing, i.e., they buy only one platform and the market is covered, i.e., all consumers buy from one firm or the other. Now, substituting for the utility functions, in terms of prices and licensing fees we can reduce equation (10) to

$$n^i_{u,\{F,F\}} = 1 - \frac{t\Big[p^i - p^{\backslash i}\Big] + 2\beta\Big[l^i - l^i\Big] - \Big[t + 2\beta\Big]\Big[\theta^i - \theta^{\backslash i}\Big]}{t\Big[t - 2\alpha\Big] - 4\beta^2} \tag{11}$$

Along these same lines, we can also write the specification for the demand function on the developer side of the market as

$$n^i_{d,\{F,F\}} = 1 - \frac{2\beta\Big[p^i - p^{\backslash i}\Big] + \Big[t - 2\alpha\Big]\Big[l^i - l^{\backslash i}\Big] + \Big[2\Big[\alpha - \beta\Big] - t\Big]\Big[\theta^i - \theta^{\backslash i}\Big]}{t\Big[t - 2\alpha\Big] - 4\beta^2} \tag{12}$$

As we know the demand function, we now substitute equations (11) and (12) in equation (7) and solve the objective function. This gives us Lemma 1.

Lemma 1. *There exists a unique equilibrium in the formal-formal subgame where both firms will preannounce the same prices and licensing fees*

$$p^{i*}_{\{F,F\}} = \frac{\left[\theta^i - \theta^{\setminus i}\right]}{3} + t - 2\left[\alpha + \beta\right]$$
$$l^{i*}_{\{F,F\}} = \frac{\left[\theta^i - \theta^{\setminus i}\right]}{3} + t - 2\beta$$

■

(ALL PROOFS ARE IN THE APPENDIX)

When both firms pursue formal strategy in Stage 1, firms' pricing is such that the expected market share of both sides of the market is fulfilled at equilibrium, and such a market share is independent of installed base. Lemma 1 tells us that in a formal-formal subgame, end users/developers with strong strength of taste preference are willing to pay a higher price than those with weak strength of taste preferences. This gives firms the ability to charge a premium when both sides of the market incur a severe disutility from moving away from their ideal location on the Hotelling line (Hotelling 1990). For consumers (end-users) or developers, increase in same- and/or cross-side network effect parameters increases the corresponding network effect that further enhances their utility. When both platforms with similar network effect parameters preannounce formally, firms engage in a Bertrand like competition that leads to price cutting by competing firms. The higher the ability of the platform to engage consumers through same and cross side network effects, more intense will be the competition leading to a higher price cut by both platforms at equilibrium.

3.2 Informal-Informal subgame

When the firms pursue an informal strategy in Stage 1, they are providing limited information to the market. This limits consumer understanding of the market in two ways – first, they are not aware that the market-size is going to increase and second, they are not fully aware of the new platform's improved feature-set. In other words at Stage 1 when the consumer forms his expectations about the new platform (and hence his price expectation) he has no information other

than his current knowledge of each firm. Thus his expected utility is going to be based on the installed base of each platform.

Therefore in Stage 2 when the firm sets prices, it has to take into account this limited information available to the consumer and the corresponding expectations. Observe that none of the other aspects of the horizontally segmented market are different from the formal case except for the formation of expectations, i.e., consumers are single homing and the market is covered. Also note that this is distinct and different from the market on the developer side who have the ability to form better expectations albeit with imperfect information. In order to set prices in this case, the firm incorporates the fact that the consumers expect each firm's market-size to be its initial installed base. Hence, similar to equation(9), the location of the indifferent consumer in the shared market can be obtained from

$$U^{i}_{u,I} - t\Big[x^{*}\Big]^2 = U^{\backslash i}_{u,I} - t\Big[1 - x^{*}\Big]^2 \tag{13}$$

Substituting equation (5) in the above and solving for the location of the indifferent consumer, we have

$$x^{*} = \frac{1}{2} + \frac{\alpha\Big[m^{i}_{u} - m^{\backslash i}_{u}\Big] + \beta\Big[m^{i}_{d} - m^{\backslash i}_{d}\Big] - \Big[p^{i} - p^{\backslash i}\Big] + \Big[\theta^{i} - \theta^{\backslash i}\Big]}{2t} \tag{14}$$

Note that in Stage 2 when the firms reveal their prices, the market has doubled but since the consumers have formed their price expectations in Stage 1, in order for it to be a fulfilled expectations equilibrium the firm has to take this expectation into account. In other words the firms set prices based on the network effects engendered by the installed bases rather than the true demand (from the doubled market). Thus we can write the true demand faced in Stage 2 for firm i as

$$n^{i}_{u,\{I,I\}} \Rightarrow 2x^{*} = 1 + \frac{\alpha\Big[m^{i}_{u} - m^{\backslash i}_{u}\Big] + \beta\Big[m^{i}_{d} - m^{\backslash i}_{d}\Big] - \Big[p^{i} - p^{\backslash i}\Big] + \Big[\theta^{i} - \theta^{\backslash i}\Big]}{t} \tag{15}$$

However, in setting the competitive price, the firms also have to take into account their respective profit functions and the competitors' best response. Thus, for each firm we will be substituting equation (15) in the profit function given by equation (8) and equating the first order condition to zero to solve for optimal prices. But before we can do that, we need develop the other side of market as the demand is also a function of choices made on the developer side.

We know that the developers in our marketplace, by virtue of their professional and contextual knowledge, are superior in their understanding of both the market changes and platform decisions. The developers know that the market-size is going to double due to release of new platforms. However, as discussed earlier and captured by equation (6) their understanding is attenuated by the firm's investment in seeding the information strategy. We can therefore obtain the location of the developer who is indifferent between the two firms as

$$U^{i}_{d,I} - t\Big[y^{*}\Big]^2 = U^{\backslash i}_{d,I} - t\Big[1 - y^{*}\Big]^2 \tag{16}$$

Substituting equation (6) in the above and solving for the location of the indifferent developer, we have

$$y^{*} = \frac{1}{2} + \frac{k\beta\Big[n^{i}_{u} - n^{\backslash i}_{u}\Big] - \Big[l^{i} - l^{\backslash i}\Big] + \Big[\theta^{i} - \theta^{\backslash i}\Big]}{2t} \tag{17}$$

This gives us the developers demand function faced by firm i as

$$n^{i}_{d,\{I,I\}} \Rightarrow 2y^{*} = 1 + \frac{k\beta\Big[n^{i}_{u} - n^{\backslash i}_{u}\Big] - \Big[l^{i} - l^{\backslash i}\Big] + \Big[\theta^{i} - \theta^{\backslash i}\Big]}{t} \tag{18}$$

Substituting the consumer demand from equation (15) appropriately, we have

$$n^{i}_{d,\{I,I\}} = 1 - \frac{2k\beta\Big[p^{i} - p^{\backslash i} - \alpha\Big[m^{i}_{u} - m^{\backslash i}_{u}\Big] - \beta\Big[m^{i}_{d} - m^{\backslash i}_{d}\Big]\Big] + l^{i} - l^{\backslash i} - \Big[t + 2k\beta\Big]\Big[\theta^{i} - \theta^{\backslash i}\Big]}{t^2} \tag{19}$$

Now that we know the demands functions we can substitute equations (15) and (19) in equation (8) for both the firms and obtain subgame prices and licensing fees. Thus, solving for equilibrium conditions, we have the following in Lemma 2.

LEMMA 2. *There exists a unique equilibrium in the informal-informal subgame where the platforms' licensing fees is given by*

$$p^{i*}_{\{I,I\}} = t + \frac{\left[\left[\theta^i - \theta^{\backslash i}\right] + 3t^2\left[\alpha\left[m^i_u - m^{\backslash i}_u\right] + \left[-6k + m^i_d - m^{\backslash i}_d\right]\beta + \left[\theta^i - \theta^{\backslash i}\right]\right]\right]}{9t^2 - 8k^2\beta^2} \blacksquare$$
$$l^{i*}_{\{I,I\}} = t + \frac{t\left[2k\beta\left[\alpha\left[m^i_u - m^{\backslash i}_u\right] + \beta\left[m^i_d - m^{\backslash i}_d\right] + \theta^i - \theta^{\backslash i}\right] + 3t\left[\theta^i - \theta^{\backslash i}\right]\right]}{9t^2 - 8k^2\beta^2}$$

Lemma 2 tells us that in an informal-informal subgame, a platform that provides higher intrinsic benefit to its participants and has a higher installed base of users and developers, is able to charge a higher licensing fees when it incurs a higher cost and provides a richer information about market size (k is high). However, for a platform with similar characteristics, prices do not necessarily increase in k. This is due to the inability of such a platform to influence user expectations through an informal strategy.

3.3 Formal-Informal (Informal-Formal) subgame

Having examined the subgames where firms are symmetric in their preannouncement strategies, in this section we examine the subgame where one firm may pursue a formal preannouncement while another pursues the informal strategy of investing in seeding social media networks. Therefore the utilities for consumers and developers of one firm are given by equations (3) and (4) while those of the other are given by equations (5) and (6).

In the subgame where the two platforms pursue asymmetric preannouncement strategies, the users and developers on the platform form expectations depending on the platform's strategy (formal or informal). Without loss of generality, consider the case when the focal firm pursues the formal strategy and where the competitor pursues an informal preannouncement strategy. As earlier we can find the indifferent consumer at some x in the Hotelling line where the firms located

at the two ends are pursuing different strategies. The location of this consumer can be obtained by solving

$$U^{i}_{u,F} - t\left[x^{*}\right]^{2} = U^{\backslash i}_{u,I} - t\left[1 - x^{*}\right]^{2} \tag{20}$$

This gives us

$$x^{*} = \frac{1}{2} + \frac{\alpha\left[n^{i}_{u} - m^{\backslash i}_{u}\right] + \beta\left[n^{i}_{d} - m^{\backslash i}_{d}\right] - \left[p^{i} - p^{\backslash i}\right] + \left[\theta^{i} - \theta^{\backslash i}\right]}{2t} \tag{21}$$

Considering the doubling of the market in Stage 2, we can derive the demand functions for both the focal firm and the competitor as given by

$$\begin{aligned} n^{i}_{u,\{F,I\}} &= \frac{-t\left[p^{i} - p^{\backslash i}\right] + t\left[t - m^{\backslash i}_{u}\alpha + \beta\left[1 - m^{\backslash i}_{d}\right]\right] - \beta\left[l^{i} - l^{\backslash i}\right] - 2k\beta^{2} + \left[t + \beta\right]\left[\theta^{i} - \theta^{\backslash i}\right]}{t\left[t - \alpha\right] - \left(1 + k\right)\beta^{2}} \\ n^{\backslash i}_{u,\{F,I\}} &= \frac{t\left[\left[p^{i} - p^{\backslash i}\right] + t - \alpha\left[2 - m^{\backslash i}_{u}\right]\right] + \beta\left[\left[l^{i} - l^{\backslash i}\right] - t\left[1 - m^{\backslash i}_{d}\right]\right] - 2\beta^{2} - \left[t + \beta\right]\left[\theta^{i} - \theta^{\backslash i}\right]}{t\left[t - \alpha\right] - \left[1 + k\right]\beta^{2}} \end{aligned} \tag{22}$$

Along the same lines we can also derive the demand functions in the developer market as

$$\begin{aligned} n^{i}_{d,\{F,I\}} &= \frac{\left[\begin{array}{l}\left[p^{i} - p^{\backslash i}\right] - \left[\theta^{i} - \theta^{\backslash i}\right] - t + \alpha m^{\backslash i}_{u} + \beta m^{\backslash i}_{d} \\ + \dfrac{\left[\left[t - \alpha\right]\left[\begin{array}{l}-t\left[p^{i} - p^{\backslash i}\right] + t^{2} - t\left[\alpha m^{\backslash i}_{u} + \beta m^{\backslash i}_{d}\right] \\ -\beta\left[l^{i} - l^{\backslash i}\right] + t\beta - 2k\beta^{2} + \left[t + \beta\right]\left[\theta^{i} - \theta^{\backslash i}\right]\end{array}\right]\right]}{t^{2} - t\alpha - \left(1 + k\right)\beta^{2}}\end{array}\right]}{\beta} \\ n^{\backslash i}_{d,\{F,I\}} &= 2 - \frac{\left[\begin{array}{l}\left[p^{i} - p^{\backslash i}\right] - \left[\theta^{i} - \theta^{\backslash i}\right] - t + \alpha m^{\backslash i}_{u} + \beta m^{\backslash i}_{d} \\ + \dfrac{\left[\left[t - \alpha\right]\left[\begin{array}{l}-t\left[p^{i} - p^{\backslash i}\right] + t^{2} - t\left[\alpha m^{\backslash i}_{u} + \beta m^{\backslash i}_{d}\right] \\ -\beta\left[l^{i} - l^{\backslash i}\right] + t\beta - 2k\beta^{2} + \left[t + \beta\right]\left[\theta^{i} - \theta^{\backslash i}\right]\end{array}\right]\right]}{t^{2} - t\alpha - \left(1 + k\right)\beta^{2}}\end{array}\right]}{\beta} \end{aligned} \tag{23}$$

Substituting these demands into the respective profit functions, we can now derive the prices and licensing fees for this subgame. By symmetry, we can similarly compute the prices and licensing fees for the Informal-Formal subgame. This gives us Lemma 3.

LEMMA 3. *There exists a unique equilibrium in the subgame of asymmetric strategies (the prices and licensing fees are provided in the appendix).* ■

3.4 Subgame perfect Nash equilibrium (SPNE) – Analyses of identical firms

In order to characterize overall firm preannouncement strategies, having derived the subgame equilibria, we now have to identify those that are subgame perfect Nash equilibria (SPNE). For a subgame equilibrium, say Formal-Formal, to be SPNE we need that

$$\pi^{i}_{\{F,\{F,I\}\}} \geq \pi^{i}_{\{I,\{F,I\}\}} \quad \text{and} \quad \pi^{\backslash i}_{\{\{F,I\},F\}} \geq \pi^{\backslash i}_{\{\{F,I\},I\}}$$

If this SPNE is unique in pure strategies, both firms must find that only choosing formal preannouncement strategies dominates any others in the solution space. By symmetry, similar logic applies to the Informal-Informal and Informal-Formal (Formal-Informal) cases. As can be seen from the characterizations of the subgames each equilibrium is unique in pure strategies but their existence is bounded by certain parameter relationships. These include network effects, investment costs, strength of preferences amongst others and so far in our analyses and subgame development we considered the general case where the two firms can potentially differ in their installed bases $\left(m^{i}, m^{\backslash i}\right)$ and also in the value of their platforms to the consumer/developer$\left(\theta^{i}, \theta^{\backslash i}\right)$. While we can pursue this line of analyses in exploring the potential SPNEs, for ease of exposition and to focus specifically on product and market characteristics affecting equilibrium outcome, we restrict our discussion in this section to identical firms.

Henceforth we assume both firms start with the same installed base $\left(m^{i} = m^{\backslash i} = \frac{1}{2}\right)$ and that their platforms provide an identical value$\left(\theta^{i} = \theta^{\backslash i} = \theta\right)$. Thus we conduct our SPNE analyses for identical firms. For exposition we choose to develop our characterization of the SPNE through identification of different markets where such identical firms may engage in a duopoly and where

these markets are defined by consumers' (developers') strength of preferences (t). In other words, it is evident from the subgame analyses that the parameter t plays a significant role in defining the boundaries of equilibrium regions and thus can be employed to generate cases along which the firms' duopolistic behavior might differ. Lemma 4 identifies such distinct markets where these firms may compete.

LEMMA 4. *In the duopoly of identical firms, the strength of consumer's (developer's) preferences determine firms' equilibrium strategies. For a given set of network effects* (α,β) *and investments* (k,c)*, five distinct types of markets, based on consumers' (developers') strength of preferences* (t) *can be defined as follows:*

(i) $t \in [0,t_1]$ *where* $t_1 = \max\left(2k\beta, k\beta + \frac{ck}{2}\right)$

(ii) $t \in [t_1,t_2]$ *where* $t_2 = \frac{4}{5}[\theta + k\beta]$

(iii) $t \in [t_2,t_3]$ *where* $t_3 = \max\left(2[\alpha + \beta], \frac{c}{2} + \alpha + 2\beta\right)$

(iv) $t \in [t_3,t_4]$ *where* $t_4 = \frac{4}{5}[\theta + 3\beta]$

(v) $t \in [t_4,t_{\max}]$ *where* $t_{\max} = \frac{4}{5}[\theta + 3[\alpha + \beta]]$

The parameter t which is the 'transport cost' coefficient, essentially captures the fact that consumers (developers) suffer a disutility when they consume or develop for a platform that is not their ideal. Thus greater this value, greater is their disutility and thus from a firm's point of view, they have to offer a greater discount to incentivize consumers in such markets to 'move' from their ideal location.

Lemma 4 tells us that from the point of view of equilibria in preannouncement strategies, there are five distinct types of markets from case (i) where users don't suffer much disutility in

using the platforms at either end to case (v) where such disutility can be quite high implying that the surplus that the firm is able to extract from consumers located away from the ends can be quite small.

Proposition 1. *In the duopoly of identical firms, there is no SPNE in a market where consumers' (developers') strength of preferences are very weak (case (i)) or very strong (case (v)).*

Proposition 1 tells us about the SPNE outcomes in two very different kinds of markets. It tells us that in markets where users' preferences are very strong such that offering a platform that is even a little away from their ideal will lead to a large reduction in the surplus that can be extracted. Particularly given that the market has to be covered and given that the platforms are located at the ends, the available range of prices (and licensing fees) quickly reduces since the user in the middle (receiving a platform farthest from the ideal offering) also has to receive non-zero utility. Thus the lack of a pure strategy equilibrium in such markets is a reflection of firms' inability to balance the competitive pressures on prices and users' reduced surplus.

On the other extreme are markets where consumers (developers) may be more willing and able to use (develop for) platforms that are not their ideal, i.e., where preferences or tastes are not strong enough to create a large disutility from using a non-ideal product. Consider the extreme case of such a market – one where t is close to zero or negligible; in such a market the two platforms at the two ends become pure substitutes for consumers on the Hotelling line leading to pure price competition. Firms might be incentivized to constantly undercut also because consumer surplus in the market is highest in this case and thus providing more price ranges to respond with. Our findings in Proposition 1 essentially suggest that until there is at least a minimum strength of these preferences, constant undercutting by the two firms may lead to conditions that do not yield any equilibrium outcomes. Proposition 2a below provides us with an understanding

of such a threshold such that markets characterized above this value may enjoy equilibrium outcomes.

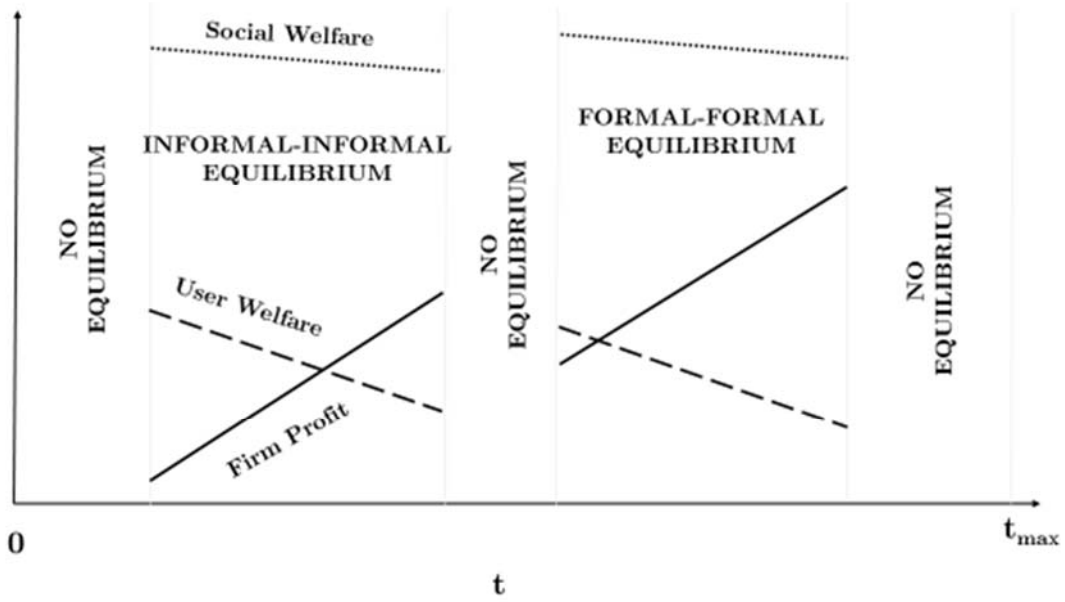

Figure 1: Market types and equilibrium strategies

Proposition 2a. *In the duopoly of identical firms, in markets where consumers' (developers') have relatively weak preferences (as defined by case (ii) in Lemma 4), in equilibrium, both firms will engage in informal preannouncement strategies.*

Proposition 2b. *In the duopoly of identical firms, in markets where consumers' (developers') have relatively strong preferences (as defined by case (iv) in Lemma 4), in equilibrium, both firms will engage in formal preannouncement strategies.*

Proposition 2c. *In the duopoly of identical firms, there is no equilibrium in asymmetric preannouncement strategies.*

Propositions 2a and 2b characterize two different kinds of markets where the disutility associated with consuming a product that is not a user's ideal, are relatively low and high respectively. The strength of preferences in such markets lie within the threshold discussed in Proposition 1. In

order to understand the economic intuition behind these equilibrium strategies it is first important to understand pricing and licensing decisions for each preannouncement strategy. In the duopoly of identical firms, the prices and licensing in the Formal-Formal equilibrium and the Informal-Informal equilibrium are given by

$$\begin{array}{ll} p^{i*}_{\{F,F\}} = t - 2\big[\alpha + \beta\big] & l^{i*}_{\{F,F\}} = t - 2\beta \\ p^{i*}_{\{I,I\}} = t - 2k\beta & l^{i*}_{\{I,I\}} = t \end{array} \tag{24}$$

First we can see that the prices and licensing fees in the symmetric informal case are higher than that in the formal case. At a first glance, this is surprising because the consumers in the former form their expectations on the basis of the smaller market (installed base) rather than when they are aware that the new platform will bring in a market twice-in-size. And given that the utilities are increasing in market size one would expect that the firms have an option of charging higher prices when consumers expect to get higher utilities.

However, this intuitive explanation is trumped by a combination of competitive elements and the lack of a true price-dependent demand from the point of view of the consumer. In other words, since both firms know that consumers expect the demand to be the installed base (strong fulfilled expectations equilibrium), price is not an effective instrument to incentivize consumers to switch. This logic also applies to the lack of the same-side network effect parameter in prices, i.e., price is not an instrument that affects total same-side network effects as demand is fixed. Hence both firms charge as high a price as possible without fear of undercutting. Note that t or the strength of preferences essentially provides the bound for prices, i.e., more the cost of moving for a consumer, more is the firm able to able to capitalize. This element comes directly from the Hotelling model (Hotelling 1990) and while prices are increasing in this parameter it important to note that in order for the farthest away consumer to continue to receive positive utility, θ or the intrinsic value of the platform should be high enough. It is also interesting to note that prices do

not involve this intrinsic value when the platforms provide identical value to the users, i.e., identical firms have no way of extracting surplus from any platform improvements except through externality-related factors.

Note that both I-I and F-F prices are decreasing in the cross-side network effect parameter (β). This tells us that in equilibrium, the firms will discount their prices by a factor of the cross side parameter, i.e., the firm finds it optimal to discount the price on user-side so as to stimulate demand on developer. However, note that while the firm does this for the developer side as well in the F-F case, it does not attempt to stimulate demand in the same fashion and charges the maximum possible price of t to the developer in the I-I case. The simple intuition is that the perceived demand (by the user) cannot be stimulated in the informal case as the user believes that market size is the installed base. These results reflect some of the findings from traditional Hotelling models as well as those observed in platforms models of Armstrong (2006) and Rochet and Tirole (2003). The key differences here is not only the absence of a marginal cost and presence of same-side network effect but also the differing weak and strong user expectations in the fulfilled expectations equilibria. Thus our findings provide a richer understanding of price and license setting when preannouncement strategies affect fulfilled expectations.

As a result of higher of prices and licensing fees, we can see that the profits to firms in the Informal-Informal subgame are always higher. Thus one would expect that in all kinds of markets the firms' preferred strategy would be to engage in informal preannouncements. However as discussed earlier in some types of markets (with low strength of preferences) there is no equilibrium solution and for some others F-F is the SPNE. These results stem from the fact that even if profits of I-I appear to be higher, other key conditions may not be satisfied in order of I-I to be SPNE. Primary among them is our requirement that prices need to be positive; note that this is

a condition we impose since in our model we do not consider incentivizing one side through subsidies. While this is beyond the scope of the current paper, it is perfectly legitimate to explore platform strategies where one side is given a product for free (or even with a coupon) while the surplus is extracted from the other side. While this positive requirement provides us the minimum threshold for the strength of preferences we also need to ensure that the market is covered, i.e., even the user farthest away (the user indifferent to either platforms) from the ends needs to enjoy non-negative utility. This condition provides us the upper threshold of t such that these markets can still sustain an I-I equilibrium.

Note that the existence of a formal equilibrium depends on strong strength of preferences – consumers in the market need to find moving away from their ideal platform to be costly enough for this strategy to be subgame perfect. In this strategy since consumers (developers) have an expectation of price (license) dependent demand, firms not only discount prices and licensing fees but they also further discount the price by a factor of the same-side network effect parameter. And indeed by construction the existence of this equilibrium is also independent of firms' investment in informal preannouncement$\left(k\right)$. These markets will sustain the F-F equilibrium as long as the platforms' intrinsic value is high enough to cover the market.

We also see that there will be no SPNE in asymmetric equilibrium and this can also be attributed primarily to the fact that firm profits are always higher under informal strategies as long as it is viable in that market. When it is not viable due to conditions discussed earlier neither firm can practice informal preannouncement so both will engage in formal preannouncements.

PROPOSITION 3a. *In the duopoly of identical firms, in markets where consumers' (developers') have relatively average preferences (as defined by case (iii) in Lemma 4), there is no equilibrium in preannouncement strategies.*

PROPOSITION 3b. *In the market described in Proposition 3a, if the intrinsic value of the platforms to the consumers is higher than a threshold, then the firms will engage in informal preannouncement strategies in equilibrium.*

PROPOSITION 3c. *The case described in Proposition 3a ceases to exist when firms make large investments in their informal strategy. Such a market will be identical to that in Proposition 2 where both firms engage in informal strategies in equilibrium.*

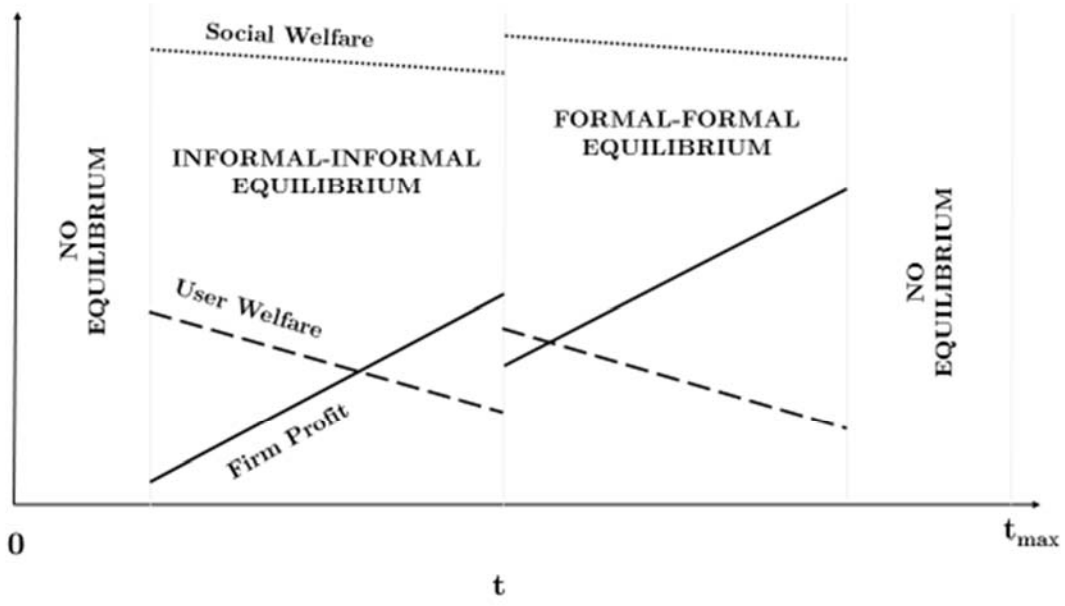

Figure 2: Duopoly outcomes in markets with high intrinsic platform value

Our results suggest that there are markets where consumers have some intermediate strength of preferences where neither informal nor formal are equilibrium preannouncement strategies. Between the thresholds of the upper bound of t where I-I becomes infeasible and where F-F is a feasible outcome is descriptive of markets where the strength of preferences are not strong enough to sustain market coverage for informal preannouncements and positive profits for the formal strategy. However, unlike other markets where the existence of equilibrium is more less independent of the informal firms' investment in preannouncement and the platforms' intrinsic value

to the users, in these markets defined by case iii in Lemma 4 both the firm-controllable factors play a role.

Proposition 3b tells us that when the non-externality based, i.e., the intrinsic value of the platforms is high enough then even these markets with intermediate strength of preferences can sustain an equilibrium in informal preannouncement strategies. In theory, firms can improve upon the intrinsic value provided by their platforms – our findings have already shown that such improvements, when identical, have no bearing on the competitive price, demand or profits. The only place where it plays a role in aiding firm strategies is when it allows for the expansion of the equilibrium regions in the markets such as those discussed in Lemma 4 case (iii).

The amount of investment a firm might make in its informal preannouncement strategy can possibly be under the firm's control. Our finding suggests that lower investments (smaller k) can be considered generally beneficial to the firm in that total costs are lower, prices are higher and so are profits. And thus while this is a largely positive impact, Proposition 3c tells us that for such markets defined by Lemma 4 case (iii), firms are better off with larger investments in their informal preannouncement strategies so as to ensure equilibrium outcomes.

Proposition 4. *In the duopoly of identical firms, for a given equilibrium strategy, firm profits are increasing in the consumers' (developers') strength of preferences while consumer and social welfare are decreasing in this factor.*

Both figures 1 and 2 capture the changes in profits and welfare in equilibrium with respect to differing strength of preferences. This parameter fundamentally captures the disutility a consumer gets when he/she has to consume a product other than his ideal. Said in another fashion, this parameter reflects the incentive a competitive firm has to provide to capture a focal firm's consumer. Indeed this parameter has also been operationalized as market power in other variants of

the Hotelling model (Armstrong 2006). It is therefore not surprising that firm profits are increasing in this factor. On the other hand given how this factor restricts or increases switching costs for users, it is no wonder that consumer welfare is decreasing. And since the rate at which user welfare is decreasing is greater than the rate at which profits are increasing, we can see that social welfare is also decreasing with this parameter.

We can also see that even if the intrinsic value of the platform plays no role in firm prices and profits, not surprisingly it plays an important role in improving consumer welfare. Similarly we can also see that all the network externalities (both same and cross-side) improve consumer welfare while they reduced firm profits. This has always been a challenge to firms in product markets that exhibit externalities – while these increase consumer utilities, how does one internalize these externalities and extract surplus? Our findings suggest that while a monopoly may be in a position to internalize these externalities easily, in a competitive market they largely contribute to welfare improvement. As our analyses of asymmetric firm shows, firm stand much to gain from these parameters if they can be a source of differentiation.

4. Conclusion

Our work seeks to make contributions to two important areas of interest to marketers. One, we wish to provide a better understanding of competition between platform-firms – a less studied phenomenon as compared to product competition. Second, we want to develop an abstraction of informal preannouncement strategy that is pursued by many firms whose platform enjoy network effects. The primary goal of this exercise is to shed light on this strategic choice in preannouncement games, hitherto not examined in extant literature. Our abstraction and model allows us to (i) Accommodate for the fact that firms compete on both prices and licensing fees and (ii) Incorporate the differential understanding of informal preannouncements exhibited by users and the more sophisticated game-developers. Through a careful development of fulfilled expectation

formation, critical for markets with network effects, we are able to identify several market conditions that dictate the pursuance of one strategy over the other.

While we are able to technically demonstrate equilibrium existence and associated conditions when firms are heterogeneous in market share, product value, etc., we restrict a majority of our analyses to identical firms so as to specifically bring out the differences in adoption of the two strategies. A first understanding provided by our work is that both the existence of equilibria and the derived optimal prices/licensing fees is a function of users' (developers') strength of taste-preferences. To the marketers this means that prior to the adoption of a preannouncement strategy, they need to fully understand the relative disutilities that users (developers) suffer when they do not a get a platform suited to their taste. Fundamentally this factor plays a critical role in characterizing the duopoly markets, firm strategies and existence of equilibria.

Our results show that prices and licensing fees are higher under informal preannouncement strategy and generally this strategy dominates the pursuance of the more well-known formal preannouncement. At the surface, the tension illustrated by the informal strategy is between the lowered cost of deferring commitment to the market and the potential lack of control over market-size through network effects (since the user side does not comprehend informal strategy well, they do not incorporate the doubled market size in their willingness to pay estimation). Curiously this appears to be beneficial to the competing firms since responding to the strict market-size (and therefore price) expectations, firms set prices on the basis of the installed-base. It turns out therefore that there is little price competition on the user side and the competition is more engendered on the developer side where through licensing fees, the market-size can be manipulated. Thus the 'strong expectations' in the user-side tempers competition leading to a more favorable situation for the firms. However, when market exhibits high strength of user (developer) preferences, firms prefer the formal announcement strategy.

Our model and discussions are for markets where users exhibit single-homing. It may however be possible that in some markets multi-homing is an option. For example, developers may design games for both consoles paying licensing fees to both. While as a first model of informal preannouncement, the current paper does not explicitly consider this scenario, we believe it possible to model this variant as an extension to our current model.

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Appendix A

Proof of Lemma 1: Both firms make formal preannouncement

The utility derived by users and developers when both firms make a formal preannouncement is given by equations (3) and (4) respectively. Equating these utilities for an indifferent user, we get the location of the indifferent user along the unit length Hotelling line in Stage 1. Users and developers are fully aware that the market size will increase when the platforms are released in Stage 2. Thus, we can write the new demand function of each firm from the user-side (n_u^A and n_u^B) as shown in equation (10) and reduce it to a form shown in equation (11). Similarly, we can derive the demand function on the developer side of the market (n_d^A and n_d^B) as shown in equation (12). Substituting the demand function of firm i from the user and developer sides, given by equations (11) and (12) respectively, in its profit function as in equation (7) and solving the first order conditions of the profit with respect to the decision variables p^i (prices) and l^i (licensing fees), i.e., $\frac{\partial \pi_F^i}{\partial p^i} = 0$ and $\frac{\partial \pi_F^i}{\partial l^i} = 0$ we get, $p^{i*}_{\{F,F\}} = \frac{\left[\theta^i - \theta^{\backslash i}\right]}{3} + t - 2\left[\alpha + \beta\right]$, $l^{i*}_{\{F,F\}} = \frac{\left[\theta^i - \theta^{\backslash i}\right]}{3} + t - 2\beta$.

Note that the second order conditions necessary for concavity of profits are $\frac{\partial^2 \pi_F^i}{\partial {p^i}^2} < 0$ and $\frac{\partial^2 \pi_F^i}{\partial {l^i}^2} < 0$. Therefore, for $p^{i*}_{\{F,F\}}$ and $l^{i*}_{\{F,F\}}$ to be profit maximizing, the following conditions must be true: $t - 2\alpha > 0$ and $t\big[t - 2\alpha\big] - 4\beta^2 > 0$

Proof of Lemma 2: Both firms make informal preannouncement

The utility derived by users and developers when both firms make an informal preannouncement is given by equations (5) and (6) respectively. Equating these utilities for an indifferent user, we get the location of the indifferent user along the unit length Hotelling line in Stage 1 as shown in equation(14). The informal preannouncement provides limited information to the market. The consumer forms his expectations about the new platforms in terms of utility and price based on his current knowledge of each firm. Thus, his expected value is based on the installed base of each platform and the firms set prices based on the expected market share of consumers to be installed base rather than true demand from the doubled market. Thus, the true demand of the user-side of the market is given by equation(15). The developers know that the market-size is going to double due to release of new platforms. However their understanding is limited by the firm's investment in seeding the informal strategy. From equating the indifferent developer's utility functions as shown in equation (16), the location of the indifferent developer is given by equation (17) and developer's demand function faced by the firm is given by equation (18). Substituting the demand function of firm i from the user and developer sides, given by equations (15) and (18) respectively, in its profit function as in equation (8) and solving the first order conditions of the profit with respect to the decision variables p^i (prices) and l^i (licensing fees), i.e., $\frac{\partial \pi_I^i}{\partial p^i} = 0$ and

$\frac{\partial \pi_I^i}{\partial l^i} = 0$ we get, $p^{i*}_{\{I,I\}} = t + \frac{\begin{bmatrix}\left[\theta^i - \theta^{\backslash i}\right] + 3t^2\left[\alpha\left[m_u^i - m_u^{\backslash i}\right] + \left[-6k + m_d^i - m_d^{\backslash i}\right]\beta + \left[\theta^i - \theta^{\backslash i}\right]\right] \\ +4k^2\beta^2\left[-\alpha\left[m_u^i - m_u^{\backslash i}\right] + \left[4k - \left[m_d^i - m_d^{\backslash i}\right]\right]\beta - \left[\theta^i - \theta^{\backslash i}\right]\right]\end{bmatrix}}{9t^2 - 8k^2\beta^2}$ and

$l^{i*}_{\{I,I\}} = t + \frac{t\left[2k\beta\left[\alpha\left[m_u^i - m_u^{\backslash i}\right] + \beta\left[m_d^i - m_d^{\backslash i}\right] + \theta^i - \theta^{\backslash i}\right] + 3t\left[\theta^i - \theta^{\backslash i}\right]\right]}{9t^2 - 8k^2\beta^2}$ .Note that the second order conditions necessary for concavity of profits are $\frac{\partial^2 \pi_I^i}{\partial p^{i^2}} < 0$ and $\frac{\partial^2 \pi_I^i}{\partial l^{i^2}} < 0$ are always satisfied. Therefore, $p^{i*}_{\{I,I\}}$ and $l^{i*}_{\{I,I\}}$ are profit maximizing.

Proof of Lemma 3: Asymmetric preannouncement strategy

We analyze firm's asymmetric preannouncement strategy. When firm i preannounces formally, and firm $\backslash i$ preannounces informally, the location of the indifferent user (denoted as x^*) is computed by equating the utility functions in equation (20) as shown in equation(21). Since the market doubles in Stage 2, the demand functions of users for both firms are given as $n^i_{u,\{F,I\}} = 2x^*$ and $n^{\backslash i}_{u,\{F,I\}} = 2\left(1 - x^*\right)$. Similarly, the location of the indifferent developer can be computed by equating equations (4) and (6): $U^i_{d,F} - t\left[y^*\right]^2 = U^{\backslash i}_{d,I} - t\left[1 - y^*\right]^2 \Rightarrow y^* = \frac{1}{2} + \frac{\beta\left[n_u^i - kn_u^{\backslash i}\right] - \left[l^i - l^{\backslash i}\right]}{2t}$. The demand function of developers in stage 2 (when the market doubles) is given by $n^i_{d,\{F,I\}} = 2y^*$ and $n^{\backslash i}_{d,\{F,I\}} = 2\left(1 - y^*\right)$. Solving the demand functions simultaneously, we get the demand functions of users and developers as a function of prices, licensing fees and installed bases as shown in equations (22) and (23). Substituting these demand functions back into the objective functions of firm i (equation (7)) and firm $\backslash i$ (equation (8)), and solving the first order conditions with respect

to prices and licensing fees we can derive the prices and licensing fees for the asymmetric preannouncement strategy (the expressions for prices and licensing fees are shown in the online Appendix B).

Proof of Lemma 4: SPNE of Identical Firms

There could be four possible SPNEs: Symmetric Strategies (Formal-Formal or Informal-Informal) and Asymmetric Strategies (Formal-Informal or Informal-Formal). The game is solved through backward induction starting with pricing sub-game (the subgame equilibrium prices and licensing fees are shown in Lemma 1 and 2 for symmetric strategies and Lemma 3 for asymmetric strategies). While we have computed the sub-game equilibrium price and licensing fees for non-identical firms, we specifically are interested in understanding the impact of market characteristics on SPNE of identical firms. For identical firms, $\theta^i = \theta^{\backslash i}, m_u^i = m_u^{\backslash i} = \frac{1}{2}, m_d^i = m_d^{\backslash i} = \frac{1}{2}$ and $\pi^i_{\{F,I\}} = \pi^{\backslash i}_{\{I,F\}}$. With these assumptions, we can compute the prices, licensing fees and profits for formal-formal, informal-informal and formal-informal sub-games for identical firms, according to Lemmas 1, 2 and 3 respectively.

When both firms preannounce formally, their profits are $\pi_F^{A*} = \pi_F^{B*} = 2\big[t - \alpha - 2\beta\big] - c$ while the profits of both firms announcing informally are $\pi_I^{i*} = \pi_I^{\backslash i*} = 2\big[t - k\beta\big] - kc$. Note that $\pi_I^{i*} > \pi_F^{i*}$, therefore informal-informal preannouncement strategy dominates formal-formal preannouncement strategy in regions where both strategies are feasible.

For Formal-Formal/Informal-Informal strategy to be feasible, profits must be positive and must be concave in its positive prices and licensing fees. Further the utility of users and developers must be non-negative. These necessary conditions for the feasibility of *Formal-Formal* preannouncement strategy can be summarized as:

$$\max\left(2\big[\alpha+\beta\big],\frac{c}{2}+\alpha+2\beta\right)<t<\min\left(\frac{4}{5}\big[\theta+3\big[\alpha+\beta\big]\big],\frac{4}{5}\big[\theta+3\beta\big]\right).$$

The necessary conditions for the feasibility of *Informal-Informal* preannouncement strategy can be summarized as:

$$\max\left(2k\beta,k\left[\beta+\frac{c}{2}\right]\right)<t<\min\left(\frac{4}{5}\left[\theta+\frac{2\big[\alpha+\beta\big[1+4k\big]\big]}{4}\right],\frac{4}{5}\big[\theta+k\beta\big]\right)$$

The derivation of equilibrium regions shown in Lemma 4 are given in the Online Appendix B.

Proof of Proposition 1

Proposition 1 directly follows from Lemma 4. As shown in Lemma 4, there is no equilibrium in markets characterized by very weak taste preferences of consumers such that $t\in\big[0,t_1\big]$ where $t_1=\max\left(2k\beta,k\beta+\frac{ck}{2}\right)$. Similarly when consumer taste preferences are very strong such that $t\in\big[t_4,t_{\max}\big]$ where $t_{\max}=\frac{4}{5}\big[\theta+3\big[\alpha+\beta\big]\big]$.

Proof of Proposition 2

Proposition 2a directly follows from Lemma 4. When $\frac{4}{5}\big[\theta+3\beta\big]<\max\left(2\big[\alpha+\beta\big],\frac{c}{2}+\alpha+2\beta\right)$, in markets characterized by $t\in\big[t_1,t_2\big]$ where $t_2=\frac{4}{5}\big[\theta+k\beta\big]$, formal preannouncement strategy is infeasible but informal preannouncement strategy is feasible. Therefore, in this region, Informal-Informal is a SPNE strategy. Similarly, when $\frac{4}{5}\big[\theta+3\beta\big]>\max\left(2\big[\alpha+\beta\big],\frac{c}{2}+\alpha+2\beta\right)$, in markets

characterized by $t \in [t_1, t_3]$ where $t_3 = \max\left(2[\alpha+\beta], \frac{c}{2}+\alpha+2\beta\right)$, Informal-Informal is a SPNE strategy.

Proposition 2b directly follows from Lemma 4. When $\frac{4}{5}[\theta+3\beta] < \max\left(2[\alpha+\beta], \frac{c}{2}+\alpha+2\beta\right)$, in markets characterized by $t \in [t_3, t_4]$ where $t_4 = \frac{4}{5}[\theta+3\beta]$: In this region, informal preannouncement is infeasible and therefore Formal-Formal is the SPNE. Similarly, when $\frac{4}{5}[\theta+3\beta] > \max\left(2[\alpha+\beta], \frac{c}{2}+\alpha+2\beta\right)$, in markets characterized by $t \in [t_3, t_4]$ where $t_4 = \frac{4}{5}[\theta+3\beta]$, Formal-Formal is SPNE.

Proposition 2c: Asymmetric strategy (Formal-Informal or Informal-Formal) is not feasible for identical firms since the prices and licensing fees cannot be positive simultaneously. Prices and licensing fees for formal-informal strategy for identical firms are shown in the Online Appendix B.

Proof of Proposition 3

As shown in Lemma 4, when $\frac{4}{5}[\theta+3\beta] < \max\left(2[\alpha+\beta], \frac{c}{2}+\alpha+2\beta\right)$, in markets characterized by $t \in [t_2, t_3]$ where $t_3 = \max\left(2[\alpha+\beta], \frac{c}{2}+\alpha+2\beta\right)$: In this region, both formal and informal preannouncement strategies are infeasible. Therefore there is no equilibrium strategy for identical firms in this region (Proposition 3a). From Lemma 4 (identical firms), we know that in markets characterized by moderate consumer's (developer's) strength of preferences, there is no equilibrium in preannouncement strategies in the region $t \in [t_2, t_3]$ where $t_2 = \frac{4}{5}[\theta+k\beta]$ and $t_3 = \max\left(2[\alpha+\beta], \frac{c}{2}+\alpha+2\beta\right)$. This is true when $t_2 < t_3$. However, $\frac{\partial(t_2)}{\partial(\theta)} > 0$ and $\frac{\partial(t_2)}{\partial(k)} > 0$.

Therefore, there exists a threshold on θ beyond which $t_2 > t_3$. Specifically, if $\theta > \frac{5}{4}\max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right) - k\beta$, $t_2 > t_3$ (Proposition 3b). Similarly, for sufficiently high values of k denoted by, $k > \min\left(\frac{5}{4\beta}\max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right) - \frac{\theta}{\beta}, 1\right)$, $t_2 > t_3$ (Proposition 3c). In markets characterized by the region $t_2 > t_3$, both formal-formal and informal-informal preannouncement strategies are feasible. When both firms preannounce formally, their profits are $\pi_F^{A*} = \pi_F^{B*} = 2\left[t-\alpha-2\beta\right] - c > 0$ while the profits of both firms announcing informally $\pi_I^{i*} = \pi_I^{\backslash i*} = 2\left[t-k\beta\right] - kc > 0$. Note that $\pi_I^{i*} > \pi_F^{i*}$, therefore II dominates F-F in these markets.

Proof of Proposition 4

Consumer (Developer) welfare is the net utility derived by the consumer (developer) in a market for a given preannouncement strategy. The total social welfare is the sum of consumer and developer welfare, and firm profits in a market for a preannouncement strategy. For formal-formal preannouncement strategy for identical firms, the consumer welfare is $W_{u,\{F,F\}} = \int_0^{x^*} U_{u,F}^i dx + \int_{x^*}^1 U_{u,F}^{\backslash i} dx$ where, x^* is the position of the indifferent user as shown in equation(10). The consumer welfare in a doubled market in stage 2 is $W_{u,\{F,F\}} = 6\left[\alpha+\beta\right] + 2\theta - \frac{13t}{6}$. Thus, consumer welfare is decreasing in the consumer's strength of preference. Similarly, the developer welfare in the doubled market in stage 2 can be simplified as, $W_{d,\{F,F\}} = 2\theta + 6\beta - \frac{13t}{6}$. From equation (7) and Lemma 1, for identical firms, firm profit for formal-formal strategy is $\pi_F^{i*} = 2\left[t-\alpha-2\beta\right] - c$. The social welfare in the market where both firms preannounce formally, is given as $W_{\{F,F\}} = W_{u,\{F,F\}} + W_{d,\{F,F\}} + \sum_{i\in\{A,B\}} \pi_F^i = 2\alpha + 4\beta + 4\theta - 2c - \frac{t}{3}$

.Thus, the total welfare in the F-F preannouncement strategy decreases with an increase in the strength of consumer preferences. Similarly, the consumer welfare in the market can be simplified as, $W_{u,\{I,I\}} = \alpha + \beta\big[1 + 4k\big] + 2\theta - \frac{13t}{6}$.Thus, consumer welfare is decreasing in the consumer's strength of preference. The developer welfare is $W_{d,\{I,I\}} = 2\theta + 2k\beta - \frac{13t}{6}$. Thus, developer welfare is decreasing in their strength of preference. From equation (8) and Lemma 2, for identical firms, firm profit for informal-informal strategy is $\pi_I^{i*} = 2\big[t - k\beta\big] - kc$. Since, $\frac{\partial\left(\pi_I^{i*}\right)}{\partial t} > 0$ firm profits are increasing in their strength of preference. The social welfare in a market where both firms preannounce informally, is given as

$W_{\{I,I\}} = W_{u,\{I,I\}} + W_{d,\{I,I\}} + \sum_{i\in\{A,B\}} \pi_I^i = \alpha + \beta\big[1 + 2k\big] + 4\theta - 2ck - \frac{t}{3}$. Thus, the total welfare in the informal-informal preannouncement strategy decreases with an increase in the strength of consumer preferences. Details of welfare calculations are in the Online Appendix B.

Platform Preannouncement Strategies: A Duopoly of Two-Sided Markets

Online Appendix B

Please note that this online appendix refers to equations contained in the main body of the paper.

Lemma 3: Prices and Licensing fees

The prices and licensing fees for asymmetric equilibrium in preannouncement strategies (Formal-Informal) are given below:

$$p^{i*}_{\{F,I\}} = \frac{\begin{bmatrix} 9t^3 - 3t^2\left[\left[5+m_u^{\backslash i}\right]\alpha + \left[2+3k+m_d^{\backslash i}\right]\beta - \left[\theta^i - \theta^{\backslash i}\right]\right] + \\ \beta\left[\alpha\left[\left[1+k\right]\left[6+\left[3+k\right]m_u^{\backslash i}\right]\beta + k\left[\theta^i - \theta^{\backslash i}\right]\right] + \left[1+k\right]\left[3+k\right]\beta\left[\left[2+2k+m_u^{\backslash i}\right]\beta - \left[\theta^i - \theta^{\backslash i}\right]\right]\right] \\ +t\left[3\left[2+m_u^{\backslash i}\right]\alpha^2 - \beta\left(\left[1+k\right]\left[9+k\right]\beta + k\left[\theta^i - \theta^{\backslash i}\right]\right) + 3\alpha\left[\left[2+3k+m_u^{\backslash i}\right]\beta - \left[\theta^i - \theta^{\backslash i}\right]\right]\right] \end{bmatrix}}{9t\left[t-\alpha\right] - \left[3+k\right]\left[3+2k\right]\beta^2}$$

$$p^{\backslash i*}_{\{F,I\}} = \frac{\begin{bmatrix} 9t^3 + 3t^2\left[\left[-7+m_u^{\backslash i}\right]\alpha + \left[-4-3k+m_d^{\backslash i}\right]\beta + \theta^{\backslash i} - \theta^i\right] \\ -t\left[3\left[-4+m_u^{\backslash i}\right]\alpha^2 + 3\alpha\left[\left[-4-3k+m_d^{\backslash i}\right]\beta + \theta^{\backslash i} - \theta^i\right] + \beta\left[\left[9+k\left[8+3k\right]\right]\beta + k\left[\theta^{\backslash i} - \theta^i\right]\right]\right] \\ +\beta\left[\left[1+k\right]\left[3+k\right]\beta\left[\left[4+2k-m_d^{\backslash i}\right]\beta - \left[\theta^{\backslash i} - \theta^i\right]\right] + \alpha\begin{bmatrix}\left[4\left[3+k\left[3+k\right]\right] - \left[1+k\right]\left[3+k\right]m_u^{\backslash i}\right]\beta \\ +k\left[\theta^{\backslash i} - \theta^i\right]\end{bmatrix}\right] \end{bmatrix}}{9t\left(t-\alpha\right) - \left(3+k\right)\left(3+2k\right)\beta^2}$$

$$l^{i*}_{\{F,I\}} = \frac{\begin{bmatrix} 9t^3 + \left[3+2k\right]\beta^2\left[2\left[1+k\right]\beta - \left[\theta^i - \theta^{\backslash i}\right]\right] - 3t^2\left[3\alpha + \left[2+k\right]\beta - \left[\theta^i - \theta^{\backslash i}\right]\right] - \\ t\left[\alpha\left[\left[-6+k\left[-4+m_u^{\backslash i}\right]\right]\beta + 3\left[\theta^i - \theta^{\backslash i}\right]\right] + \beta\left[9+k\left[8+2k+m_d^{\backslash i}\right]\beta - k\left[\theta^i - \theta^{\backslash i}\right]\right]\right] \end{bmatrix}}{9t\left[t-\alpha\right] - \left[3+k\right]\left[3+2k\right]\beta^2}$$

$$l^{\backslash i*}_{\{F,I\}} = \frac{\begin{matrix} 9t^3 + \left[3+2k\right]\beta^2\left[4\beta - \left[\theta^{\backslash i} - \theta^i\right]\right] + 3t^2\left[-3\alpha + \left[-4+k\right]\beta + \left[\theta^{\backslash i} - \theta^i\right]\right] \\ +t\left[\alpha\left[\left[12+k\left[-4+m_u^{\backslash i}\right]\right]\beta - 3\left[\theta^{\backslash i} - \theta^i\right]\right] + \beta\left[\left[-9+k\left[-2\left[5+k\right]+m_d^{\backslash i}\right]\right]\beta + k\left[\theta^{\backslash i} - \theta^i\right]\right]\right] \end{matrix}}{9t\left[t-\alpha\right] - \left[3+k\right]\left[3+2k\right]\beta^2}$$

Note that the second order conditions necessary for concavity of profits are $\frac{\partial^2 \pi_F^i}{\partial p^{i^2}} < 0$, $\frac{\partial^2 \pi_F^i}{\partial l^{i^2}} < 0$, $\frac{\partial^2 \pi_I^{\backslash i}}{\partial p^{\backslash i^2}} < 0$ and $\frac{\partial^2 \pi_I^{\backslash i}}{\partial l^{\backslash i^2}} < 0$ .Therefore, for $p_{\{F,I\}}^{i*}$ and $l_{\{F,I\}}^{i*}$ to be profit maximizing, the following conditions must be true: $t > \alpha$ and $t\left[t-\alpha\right] > \left[1+k\right]\beta^2$ .By symmetry, when firm i announces informally and firm $\backslash i$ announces informally, $p_{\{I,F\}}^{i*} = p_{\{F,I\}}^{\backslash i*}$, $p_{\{I,F\}}^{\backslash i*} = p_{\{F,I\}}^{i*}$, $l_{\{I,F\}}^{i*} = l_{\{F,I\}}^{\backslash i*}$ and $l_{\{I,F\}}^{\backslash i*} = l_{\{F,I\}}^{i*}$.

Lemma 4: Characterization of Equilibrium Regions.

From the feasibility conditions of Formal-Formal and Informal-Informal strategies, note that $0 < k < 1$, $\max\left(2k\beta, k\left[\frac{c}{2}+\beta\right]\right) < \max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right)$. Asymmetric strategy (Formal-Informal or Informal-Formal) is not feasible for identical firms since the prices and licensing fees cannot be positive simultaneously. Therefore, we only compare formal-formal and informal-informal subgames for analyzing the sub-game perfect Nash equilibrium in the feasible regions.

First, we consider the scenario when $\frac{4}{5}\left[\theta+3\beta\right] < \max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right)$. Thus, the following threshold on t and corresponding strategies exist:

i) $t \in \left[0, t_1\right]$ where $t_1 = \max\left(2k\beta, k\beta + \frac{ck}{2}\right)$: In this region, there is no equilibrium since both Formal-Formal and Informal-Informal strategies are infeasible for identical firms.

ii) $t \in \left[t_1, t_2\right]$ where $t_2 = \frac{4}{5}\left[\theta + k\beta\right]$: In this region, formal preannouncement strategy is infeasible but informal preannouncement strategy is feasible. Therefore, in this region, Informal-Informal is a SPNE strategy.

iii) $t \in \left[t_2, t_3\right]$ where $t_3 = \max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right)$: In this region, both formal and informal preannouncement strategies are infeasible. Therefore there is no equilibrium strategy for identical firms in this region.

iv) $t \in \left[t_3, t_4\right]$ where $t_4 = \frac{4}{5}\left[\theta+3\beta\right]$: In this region, informal preannouncement is infeasible and therefore Formal-Formal is the SPNE.

v) $t \in \left[t_4, t_{\max}\right]$ where $t_{\max} = \frac{4}{5}\left[\theta+3\left[\alpha+\beta\right]\right]$: In this region, both formal and informal strategies are infeasible. Thus, there is no equilibrium preannouncement strategy in this region.

Second, we consider the scenario when $\frac{4}{5}\left[\theta+3\beta\right] > \max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right)$. Thus, the following threshold on t exists:

i) $t \in \left[0, t_1\right]$ where $t_1 = \max\left(2k\beta, k\beta+\frac{ck}{2}\right)$: no equilibrium in this region.

ii) $t \in \left[t_1, t_3\right]$ where $t_3 = \max\left(2\left[\alpha+\beta\right], \frac{c}{2}+\alpha+2\beta\right)$: Informal-Informal is the SPNE.

iii) $t \in \left[t_3, t_4\right]$ where $t_4 = \frac{4}{5}\left[\theta+3\beta\right]$: Formal-Formal is the SPNE.

iv) $t \in \left[t_4, t_{\max}\right]$ where $t_{\max} = \frac{4}{5}\left[\theta+3\left[\alpha+\beta\right]\right]$: no equilibrium in this region.

Proposition 2: Prices and Licensing Fees for Asymmetric Equilibrium for Identical Firms

Proposition 2c: Asymmetric strategy (Formal-Informal or Informal-Formal) is not feasible for identical firms since the prices and licensing fees cannot be positive simultaneously. The prices and licensing fees for formal-informal strategy for identical firms are shown

$$p^{i}_{\{F,I\}} = \frac{\begin{bmatrix} 3t\big[6t-5\alpha\big]\big[t-\alpha\big]-3\big[5+6k\big]t\big[t-\alpha\big]\beta-\big[1+k\big]\big[2\big[9+k\big]t-\big[15+k\big]\alpha\big]\beta^2 \\ +\big[1+k\big]\big[3+k\big]\big[5+4k\big]\beta^3 \end{bmatrix}}{18t\big[t-\alpha\big]-2\big[3+k\big]\big[3+2k\big]\beta^2}.$$

$$p^{\backslash}_{\{F,I\}} = \frac{\begin{bmatrix} 3t\big[6t-7\alpha\big]\big[t-\alpha\big]-3\big[7+6k\big]t\big[t-\alpha\big]\beta+\big[-2\big[9+k\big[8+3k\big]\big]t+\big[21+k\big[20+7k\big]\big]\alpha\big]\beta^2 \\ +\big[1+k\big]\big[3+k\big]\big[7+4k\big]\beta^3 \end{bmatrix}}{18t\big[t-\alpha\big]-2\big[3+k\big]\big[3+2k\big]\beta^2}$$

$$l^{i}_{\{F,I\}} = \frac{18t^3+4\big[1+k\big]\big[3+2k\big]\beta^3-6t^2\big[3\alpha+\big[2+k\big]\beta\big]+t\beta\big[\big[12+7k\big]\alpha-\big[2+k\big]\big[9+4k\big]\beta\big]}{18t\big[t-\alpha\big]-2\big[3+k\big]\big[3+2k\big]\beta^2}$$

$$l^{\backslash}_{\{F,I\}} = \frac{18t^3+8\big[3+2k\big]\beta^3+6t^2\big[-3\alpha+\big[-4+k\big]\beta\big]-t\beta\big[\big[-24+7k\big]\alpha+\big[18+k\big[19+4k\big]\big]\beta\big]}{18t\big[t-\alpha\big]-2\big[3+k\big]\big[3+2k\big]\beta^2}.$$

Proposition 4: Welfare Analysis

Consumer (Developer) welfare is the net utility derived by the consumer (developer) in a market for a given preannouncement strategy. The total social welfare is the sum of consumer and developer welfare, and firm profits in a market for a preannouncement strategy.

First we analyze the formal-formal preannouncement strategy for identical firms. The consumer welfare is $W_{u,\{F,F\}} = \int_0^{x^*} U^i_{u,F}dx + \int_{x^*}^1 U^{\backslash}_{u,F}dx$ where, x^* is the position of the indifferent user as shown in equation (10). For identical firms, the indifferent user is located at $\frac{1}{2}$ on a unit length Hotelling line. Further, from equation (3), we know that,

$$U^i_{u,F} = \theta^i + \alpha n^i_u\left(p^i, p^{\backslash}, l^i, l^{\backslash}\right) + \beta n^i_d\left(p^i, p^{\backslash}, l^i, l^{\backslash}\right) - p^i$$

For identical firms, $n_u^i\left(p^i, p^{\backslash i}, l^i, l^{\backslash i}\right) = n_d^i\left(p^i, p^{\backslash i}, l^i, l^{\backslash i}\right) = 1$, from equation (10), and $p^i = t - 2\left[\alpha + \beta\right]$ (from Lemma 1). Therefore, the consumer welfare in the doubled market in stage 2 can be simplified as,

$$W_{u,\{F,F\}}$$
$$= 2\left[\int_0^{\frac{1}{2}}\left(\theta + \alpha + \beta - \left[t - 2\left[\alpha + \beta\right]\right] - tx^2\right)dx + \int_{\frac{1}{2}}^{1}\left(\theta + \alpha + \beta - \left[t - 2\left[\alpha + \beta\right]\right] - t\left[1 - x\right]^2\right)dx\right]$$
$$= 6\left[\alpha + \beta\right] + 2\theta - \frac{13t}{6}$$

$\frac{\partial\left(W_{u,\{F,F\}}\right)}{\partial t} < 0$. Thus, consumer welfare is decreasing in the consumer's strength of preference.

Similarly, the developer welfare **is** $W_{d,\{F,F\}} = \int_0^{y^*} U_{d,F}^i dy + \int_{y^*}^1 U_{d,F}^{\backslash i} dy$ where, y^* is the position of the indifferent user as shown in equation (10). For identical firms, the indifferent developer is located at $\frac{1}{2}$ on a unit length Hotelling line. Further, from equation (4), we know that,

$$U_{d,F}^i = \theta^i + \beta n_u^i\left(p^i, p^{\backslash i}, l^i, l^{\backslash i}\right) - l^i$$

For identical firms, $n_u^i\left(p^i, p^{\backslash i}, l^i, l^{\backslash i}\right) = 1$, from equation (10), and $l^i = t - 2\beta$ (from Lemma 1). Therefore, the developer welfare in the doubled market in stage 2 can be simplified as,

$$
\begin{aligned}
&W_{d,\{F,F\}} \\
&= 2\left[\int_0^{\frac{1}{2}}\Big(\theta+\beta-\big[t-2\beta\big]-tx^2\Big)dx+\int_{\frac{1}{2}}^{1}\Big(\theta+\beta-\big[t-2\beta\big]-t\big[1-x\big]^2\Big)dx\right] \\
&= 2\theta+6\beta-\frac{13t}{6}
\end{aligned}
$$

Note that $\dfrac{\partial\Big(W_{d,\{F,F\}}\Big)}{\partial t}<0$. Thus, developer welfare is decreasing in their strength of preference.

From equation (7) and Lemma 1, for identical firms, firm profit for formal-formal strategy is $\pi_F^{i*}=2\big[t-\alpha-2\beta\big]-c$. Since, $\dfrac{\partial\Big(\pi_F^{i*}\Big)}{\partial t}>0$ firm profits are increasing in their strength of preference.

The social welfare in the market where both firms announce formally, is given as

$$
\begin{aligned}
W_{\{F,F\}} &= W_{u,\{F,F\}}+W_{d,\{F,F\}}+\sum_{i\in\{A,B\}}\pi_F^i \\
&= 2\alpha+4\beta+4\theta-2c-\frac{t}{3}
\end{aligned}
$$

Note that $\dfrac{\partial\Big(W_{\{F,F\}}\Big)}{\partial t}<0$. Thus, the total welfare in the informal-informal preannouncement strategy decreases with an increase in the strength of consumer preferences.

Next we analyze the informal-informal preannouncement strategy for identical firms. The consumer welfare is $W_{u,\{I,I\}}=\int_0^{x^*}U_{u,I}^i dx+\int_{x^*}^{1}U_{u,I}^i dx$ where, x^* is the position of the indifferent user as shown in equation (14). For identical firms, the indifferent user is located at $\frac{1}{2}$ on a unit length Hotelling line. Further, from equation (5), we know that,

$$U^i_{u,I} = \theta^i + \alpha m^i_u + \beta m^i_d - p^i$$

For identical firms, $m^i_u = m^i_d = \frac{1}{2}$, and $p^i = t - 2k\beta$ (from Lemma 2). Therefore, the consumer welfare in the market can be simplified as,

$$\begin{aligned} & W_{u,\{I,I\}} \\ &= 2\left[\int_0^{\frac{1}{2}}\left(\theta + \frac{\alpha+\beta}{2} - \big[t - 2k\beta\big] - tx^2\right)dx + \int_{\frac{1}{2}}^{1}\left(\theta + \frac{\alpha+\beta}{2} - \big[t - 2k\beta\big] - t\big[1-x\big]^2\right)dx\right] \\ &= \alpha + \beta\big[1 + 4k\big] + 2\theta - \frac{13t}{6} \end{aligned}$$

Note that $\frac{\partial\left(W_{u,\{I,I\}}\right)}{\partial t} < 0$. Thus, consumer welfare is decreasing in the consumer's strength of preference.

Similarly, the developer welfare is $W_{d,\{I,I\}} = \int_0^{y^*} U^i_{d,I}dy + \int_{y^*}^1 U^{\backprime i}_{d,I}dy$ where, y^* is the position of the indifferent user as shown in equation (17). For identical firms, the indifferent developer is located at $\frac{1}{2}$ on a unit length Hotelling line. Further, from equation (6), we know that,

$$U^i_{d,I} = \theta^i + k\beta n^i_u\left(p^i, p^{\backprime i}, l^i, l^{\backprime i}\right) - l^i$$

For identical firms, $n^i_u\left(p^i, p^{\backprime i}, l^i, l^{\backprime i}\right) = 1$, from equation (14), and $l^i = t$ (from Lemma 1). Therefore, the developer welfare in the market can be simplified as,

$$\begin{aligned} & W_{d,\{I,I\}} \\ &= 2\left[\int_0^{\frac{1}{2}}\left(\theta + k\beta - t - tx^2\right)dx + \int_{\frac{1}{2}}^{1}\left(\theta + k\beta - t - t\big[1-x\big]^2\right)dx\right] \\ &= 2\theta + 2k\beta - \frac{13t}{6} \end{aligned}$$

$\frac{\partial\left(W_{d,\{I,I\}}\right)}{\partial t} < 0$. Thus, developer welfare is decreasing in their strength of preference.

From equation (8) and Lemma 2, for identical firms, firm profit for informal-informal strategy is $\pi_I^{i*} = 2\big[t - k\beta\big] - kc$. Since, $\dfrac{\partial\left(\pi_I^{i*}\right)}{\partial t} > 0$ firm profits are increasing in their strength of preference.

The social welfare in a market where both firms announce informally, is given as

$$\begin{aligned} W_{\{I,I\}} &= W_{u,\{I,I\}} + W_{d,\{I,I\}} + \sum_{i\in\{A,B\}} \pi_I^i \\ &= \alpha + \beta\big[1 + 2k\big] + 4\theta - 2ck - \frac{t}{3} \end{aligned}$$

Note that $\dfrac{\partial\left(W_{\{I,I\}}\right)}{\partial t} < 0$. Thus, the total welfare in the informal-informal preannouncement strategy decreases with an increase in the strength of consumer preferences.